

# SMARA UPDATE



The Quarterly Newsletter of the Department of Conservation - Office of Mine Reclamation

## OMR's 'Changing of the Guard': Bill Armstrong Retires and Doug Craig is Promoted to New Assistant Director



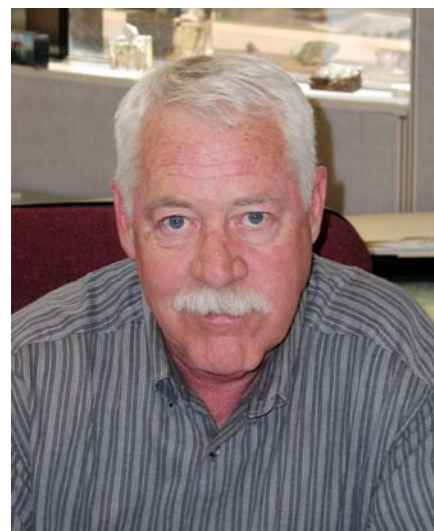
Doug Craig was promoted to Assistant Director in charge of the Office of Mine Reclamation in December 2004.

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OMR has a new chief, Doug Craig, the former manager of the Office's Abandoned Mine Lands Unit (AMLU). He replaces Bill Armstrong, who retired in December 2004. Craig brings 22 years of state service, including stints at the State Controller's Office, the State Treasurer's Office, the Department of Finance, and the Department of Conservation's Division of Recycling, to his new role as Assistant Director, Office of Mine Reclamation.

"OMR stakeholders can rest assured that we will continue to provide high quality services," said Craig. "While there has been a change in leadership, our goals remain unchanged: to improve the ultimate end-use of mined land by improving the quality of reclamation plans, to increase compliance with Surface Mining and Reclamation Act (SMARA) statutes and regulations, and to work with local, regional, state and federal partners to



Bill Armstrong, Assistant Director in charge of the Office of Mine Reclamation since June 2001, retired in December 2004.

remediate hazards posed by historic abandoned mines."

Bill Armstrong retired after more than 30 years in state service. He had been with OMR since June 2001 (See article, Page 3). "Bill achieved many successes while at OMR," said Craig. "One of my highest priorities is to maintain the momentum Bill established and to build on it."

(Continued on page 2)

Craig has been with OMR since November 2001, when he became manager of the AMLU. During the next three years, he oversaw the implementation of a statewide remediation program for physical hazards at abandoned mine sites.

Under Doug's direction, the AMLU forged partnerships with dozens of outside agencies, conducted more than 50 projects across the state, and remediated more than 150 hazardous abandoned mine features. These efforts, which were the subject of numerous newspaper articles and television spots, helped bring greater public attention to the safety problems posed by abandoned mines.

Now Craig will oversee programs dealing with both abandoned and active mines. "I'm sure there will be plenty of new challenges, but having a great staff makes the transition a lot easier," said Craig. "OMR staff are highly motivated, professional, and dedicated to their work. We have a very good team."

Among the items on his priority list: "Automating SMARA regulatory processes with the help of the new SMARA database, digitizing a mountain of old paper files, consolidating data files from each of the OMR units, and, of course, finding a new manager for the AMLU."

## SUSTAINED SUPERIOR ACCOMPLISHMENT AWARDED TO THE AMLU TEAM



From left to right; Jonathan Mistchenko, Environmental Scientist, Sarah Reeves, Environmental Scientist, and Sam Hayashi, Research Analyst II with OMR's Abandoned Mines Lands Unit (AMLU) are awarded the coveted Sustained Superior Accomplishment Award by Debbie Sareeram, Interim Department Director.

Jon, Sarah and Sam form the AMLU team which is tasked with inventorying the estimated 47,000 abandoned mines in the state. Although the team members had the skill sets required to do that job, they had to learn a variety of new ones in a hurry when the Legislature directed OMR to also begin remediation efforts on abandoned mines.

In the following two years, the AMLU team performed 42 remediation projects involving 148 potentially dangerous abandoned mine features in 12 counties. Additionally, the team has developed partnerships with a variety of state and federal agencies, and has prioritized many other dangerous abandoned mines for future remediation.

## HAPPY TRAILS BILL ARMSTRONG

Keep your powder dry and your beer cold!



Bill in his 'natural habitat' during his annual June vacation to the Black Rock Desert in central northwestern Nevada. He's been inextricably drawn to the Black Rock Desert and its environs since the Pliocene. The Black Rock itself is the dark-colored hill to Bill's lower right. It is a Devonian Period fossiliferous limestone outcrop. View is facing east (*photo 2004 by Don Dupras*).

After more than 30 years with the State, William 'Bill' Armstrong retired in December, 2004. He was appointed Assistant Director of the Office of Mine Reclamation in June 2001, and had previously managed the Department of Conservation's Division of Recycling's Market Research Branch since 1995.

While at OMR Bill devised a new format for ensuring that California's mining industry

complies with the Surface Mining and Reclamation Act (SMARA). By transferring OMR's SMARA database into Access software, it will be much more efficient to keep track of the reclamation plans, mining permits, annual reports, financial assurances, inspection reports, reporting fees, and all the other mine-related data.

Under his management, OMR made significant progress in

identifying the tens of thousands of Gold Rush era abandoned mines that pose a variety of physical hazards.

Bill is also accredited with ensuring that OMR remains credible and reliable in the eyes of the mining operators, lead agencies, the State Mining and Geology Board, and other OMR stakeholders. Enjoy your retirement Bill. It is well deserved.

## THE TROUBLE WITH ARSENIC

In 1944, a movie (a comedy no less) titled 'Arsenic and Old Lace' was released to rave reviews and laughing moviegoers. The plot revolves around a newlywed, his new wife and his kindly old aunts who are also serial killers. Their instrument of murder was of course, arsenic. Although this is a fictional account, arsenic does have a dark history. Both the ancient Greeks and the Romans utilized arsenic in medicine and as a means for eliminating enemies and political rivals.

During the Middle Ages and the Victorian Era, murder by poisoning became a cottage industry, particularly in Italy and France. Arsenic was (and is) valuable as a poisoning



Photo 1. Close up view of the sulfide minerals realgar ( $\text{As}_2\text{S}_2$ ), the more reddish colored crystals, and orpiment ( $\text{As}_2\text{S}_3$ ), the more yellow colored crystals (*photo R. Weller, courtesy of Cochise College, Arizona*).

agent because it is both odorless and tasteless. Toxicants that are undetectable by the senses are highly hazardous because they lack warning characteristics that signal in-

toxication.

Mining certain ore bodies, such as those containing high concentrations of metallic mineralization combined with high sulfur content, have the potential for exposing toxic metals to the environment. A short list of these metals include mercury, cadmium, lead, chromium, copper and arsenic. Considerable publicity of late has been given to mercury contamination, particularly in the Central Valley and Sacramento Delta as a result (at least in part) of historic mining activities. A comparison between mercury and arsenic illustrates that arsenic too is a serious environmental contaminant, and exposure may pose a higher health risk for humans than does mercury.



Photo 2. The sulfide mineral arsenopyrite ( $\text{FeAsS}$ ) is common in lode gold ores in California, and is the most significant source of arsenic associated with mining. This specimen has crystals similar in appearance to pyrite ( $\text{FeS}_2$ ) (*photo by Sarah Reeves*).

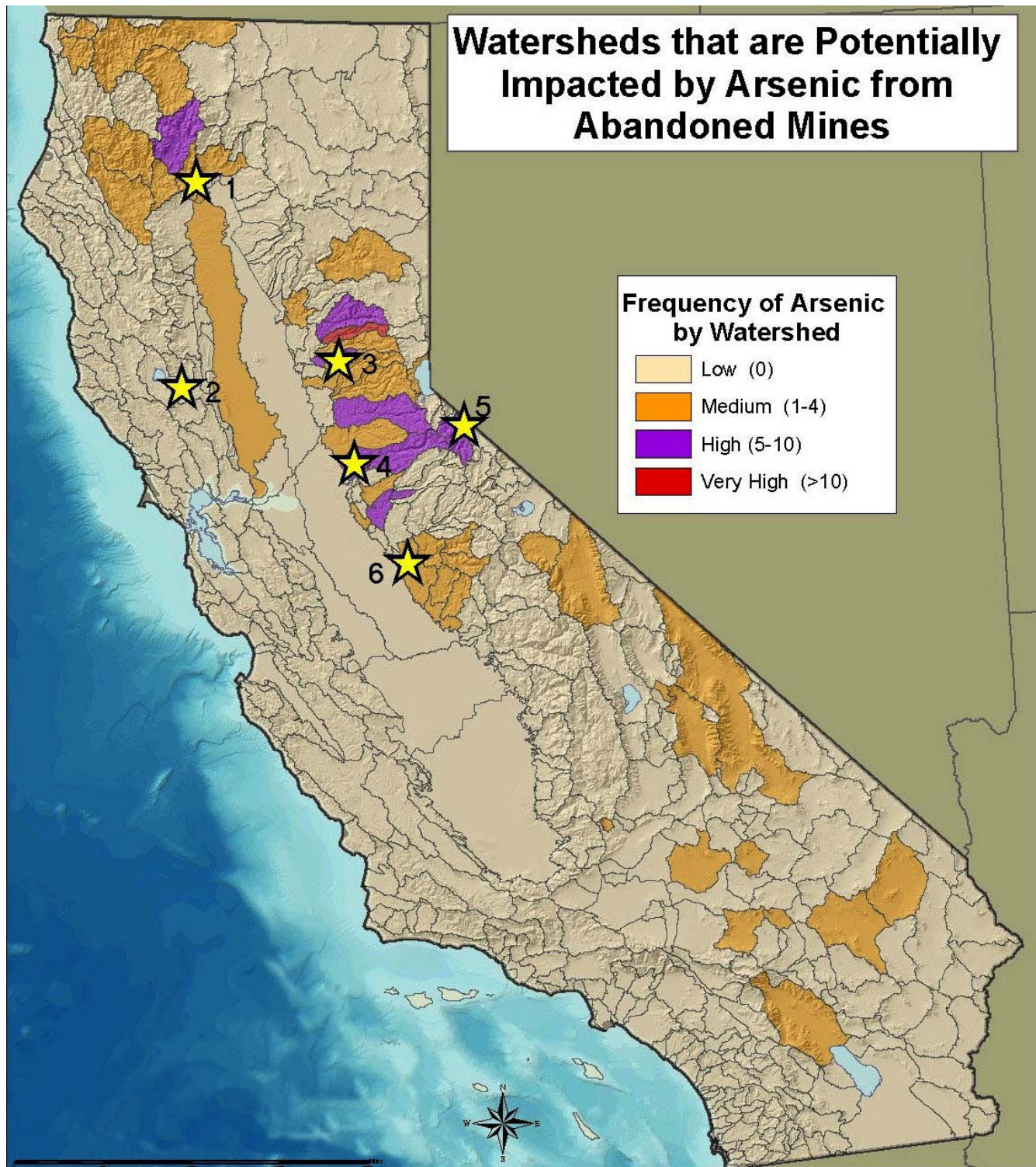


Figure 1. Map showing areas of potential arsenic contamination. Drainage from abandoned mines containing arsenic could potentially impact these watersheds. The numbered stars are locations of large sulfide mines where arsenic occurs; (1) Iron Mountain Mine, (2) Sulfur Bank Mine, (3) Lava Cap Mine, (4) Eureka Mine and the location of Sutter Creek as mentioned in the text, (5) Leviathan Mine, and (6) Jamestown Mine. These mines are currently undergoing remediation to prevent releases of arsenic into the environment. This map is adapted from data taken from the U.S. Geological Survey Mineral Resources Data System.

Arsenic is often referenced as a metal, but it lacks many metal characteristics and is more accurately called a 'metalloid.' It is ubiquitous in nature and is found in 200 or so minerals including oxides with aluminum, iron and manganese. Arsenic (As) also has high affinity for sulfur and is found in such sulfide minerals as realgar ( $\text{As}_2\text{S}_2$ ), orpiment ( $\text{As}_2\text{S}_3$ ) (Photo 2), enargite ( $\text{Cu}_3\text{AsS}_4$ ) and arsenopyrite ( $\text{FeAsS}$ ) (Photo 3). Large sulfide-enriched ore bodies in California, often containing arsenic, were extensively mined during the late 1800s and early 1900s (Figure 1). Arsenopyrite is the most significant source of arsenic associated with California mining activity.

Although environmental mercury contamination from mining activities in California has received considerable publicity (and rightfully so), arsenic also poses an environmental risk, but is not nearly as well known as its infamous metallic cousin. Nevertheless, arsenic too is a serious environmental pollutant and mining is an important source for its release to the environment.

Each year the Federal Agency for Toxic Substances and Disease Registry, is required to rank hazardous substances posing the greatest significant potential threat to human health at facilities on the National Priorities List. These fa-

cilities are more commonly referred to as 'superfund sites.' During 2003, from 275 identified hazardous constituents, arsenic was prioritized number one, lead was two, and mercury was number three. Several mines in California are superfund sites, including Iron Mountain, Sulfur Bank and Leviathan (Figure 1). Each of these mines is a significant source of arsenic.

Exceptionally large concentrations of arsenic are found in parts of Asia, Eastern India, Bangladesh, Chile, Argentina, Mexico and portions of the Western United States including California. Millions of people in Eastern India and Bangladesh are suffering from arsenic poisoning from well water containing arsenic levels exceeding 100 parts per billion (ppb). Arsenic concentrations can be much higher at mine sites. A surface seep at the Leviathan Mine in Alpine County was shown to have an average concentration of 1,800 ppb and two samples detected levels as high as 30,000 ppb! Concentrations in Leviathan Creek below the mine averaged 970 ppb. The current U.S. EPA standard for arsenic is 10 ppb.

### **Arsenic Toxicity**

Although acute arsenic poisonings are rare (these are usually intentional), very small quantities can kill. A lethal dose (acute poisoning) of 120

milligrams (that's about 1/4,000 of an ounce) would kill 50-75% of the people who are poisoned (assuming an average weight of 155 pounds per person). Symptoms of acute poisoning include difficulty in swallowing, nausea, anorexia, vomiting, abdominal pain and bloody rice-water diarrhea. Arsenic targets the cells lining the blood vessels causing capillary leakage leading to shock.

The vast majority of arsenic poisonings are chronic exposures at lower doses for a much longer period, perhaps a lifetime. It is estimated that as many as 40,000,000 people in Asia and especially India/Bangladesh are, or have been, chronically exposed to arsenic. Symptoms resulting from chronic exposure may be difficult to interpret because of the many tissues and organs impacted by arsenic poisoning. The nervous system, the skin, and the blood vessels are all important targets of arsenic poisoning.

Nervous system effects cause a slow dying back of the sensory and motor nerves, appearing as a loss of function in the hands and feet. First symptoms may appear as numbness, but this sensation progresses to a painful 'pins and needles' state, and with continued exposure may develop into weakness, loss of reflexes, and 'wrist drop' and/or 'ankle drop.'

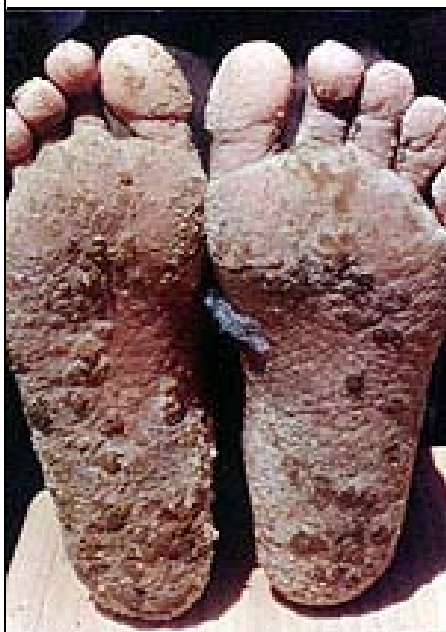


Photo 4. Chronic arsenic poisoning causes hyperkeratosis, a disease characterized by warts on the soles and palms (*anonymous photographer*).

Many of the body-wide symptoms result from damage to the blood vessels that pass through a particular tissue or organ. Without a constant blood supply delivering oxygen and nutrients the tissues supplied by the blood vessel cells cannot function and may become necrotic and die. An example is 'Peripheral Vascular Occlusive Disease,' known in Chile as Raynaud's Syndrome and as Black Foot Disease in Taiwan. Damage of the blood vessels leads to gangrene of the hands and feet and may ultimately require amputation.

One of the more prominent features of chronic arsenic poisoning is the development of unusual skin mottling with

patches of dark and light skin pigmentation. In addition, warts form 'hyperkeratosis,' especially on the palms and the soles of the feet (Photo 4). This condition is diagnostic for chronic arsenic poisoning. The skin mottling and warts are also associated with development of skin cancer, particularly squamous cell carcinoma, an invasive form of cancer that may spread to other parts of the body. The skin is a target because it contains large amounts of keratin, a protein with high sulfur content. Chronic arsenic poisoning also induces several other forms of cancer including those of the lung, kidney, bladder and a rare cancer of the blood vessels called angiosarcoma.

Arsenic exists primarily in two 'valence' states, As (III) and As (V). Both forms are toxic although As (III) is considered the more toxic of the two and probably is the form that induces cancer. The two forms each have different mechanisms for inducing toxic effects; As (III) binds to sulfur in proteins and As (V) replaces phosphorus in essential molecules. Just because As (V) is considered less toxic does not mean that it does not pose considerable risk as a poison. It exerts its own toxic effects and the body can also reduce it to the more toxic As III form.

Like metals such as mercury, cadmium, lead and chromium, arsenic III binds to rich

sources of electrons such as oxygen, nitrogen and especially sulfur. Arsenic's affinity for sulfur defines both its geochemistry and its toxicity. In mineral deposits it predominates as sulfide minerals, and in plants and animals it preferentially binds to sulfur atoms that are constituents of proteins.

There are two broad classes of proteins, structural proteins (proteins like actin that make up muscle, and keratin that is found in hair, nails and skin) and enzymes (proteins that control body function). For example, lactase is an enzyme in the intestines that breaks down the milk sugar lactose. Individuals that lack sufficient lactase to digest the lactose in milk suffer gas and intestinal cramps. People with a deficiency of this enzyme cannot digest milk sugar and are called 'lactose intolerant.' Similarly, arsenic can inactivate vital enzyme activity and create a situation as if the enzymes were not present.

Protein function – with both structural and enzyme proteins – is determined by its structure. Proteins are constructed of chains of varying combinations of 20-amino acids. One of these amino acids (cysteine) contains a sulfur atom that is a critical part of the function of many enzymes. Arsenic III will bind to this sulfur, blocking the action of the enzyme and its critical function in the person, animal or plant.

In particular, arsenic disables the enzymes that facilitate the biochemical pathways that generate energy for the body.

Without energy to operate, the cell function is altered and the cell may die. Specific required biochemical processes common to all forms of life are targeted and inactivated by arsenic; consequently all forms of life from bacteria and plants to humans are susceptible to its toxicity.

Metals generally accumulate in specific places within the body, methyl mercury in the brain, inorganic mercury in the kidneys, cadmium in the kidneys, and lead in the bone marrow and nervous system. Other tissues may be affected, but the most severe damage is often seen in the areas where the metals tend to accumulate (exceptions are common; cadmium accumulates in the kidney but has profound effects on the bones as well as kidney). Arsenic is more indiscriminate than these metals and can be found throughout the body, but the highest concentrations are localized in the skin, nervous system and blood vessels.

### **Arsenic Compared with Mercury**

For any toxin (including metals) to exert its effects, it must be absorbed into the body and transported to the site where the toxic effects are manifest.

The dangers of methyl mercury are well known, but some people mistakenly believe that only methyl mercury is dangerous. As it turns out, all forms of mercury are toxic, but environmental exposure is largely the result of mercury methylation followed by incorporation into the food chain. Only certain types of bacteria are known to methylate mercury.

Methyl mercury is considered highly toxic because it is readily absorbed into the body and because of its ability to cross the blood brain barrier into the brain. In other words, methyl mercury in this form is rapidly absorbed and transported to the site in the body where it exerts its toxic effects.

Incidentally, elemental mercury (the liquid form) poses a threat through inhalation of vapors in the lung (virtually all vapors are absorbed), but is virtually non-absorbed by the gastrointestinal tract. About 10% of inorganic mercury is absorbed following ingestion.

Arsenic is almost completely absorbed by the gastrointestinal tract (as much as 90%). Although human environmental exposure to mercury largely occurs only through the consumption of contaminated fish, environmental exposure to arsenic occurs through inhalation of arsenic laden dust, ingestion of contaminated food and drinking water. Aquatic organisms

such as fish have it even worse because their blood is in equilibrium with the water they live in. In such equilibrium, the gills are in constant contact with the water and transfer arsenic directly to the blood, which distributes it throughout the body. When concentrations are high in the water, the concentrations are high in the blood and when concentrations are low, the concentrations in the blood are low (fish kills from arsenic have been noted in creeks below some mines).

Differences in human or animal absorption, excretion and metabolism vary with all poisons. The rate of absorption/excretion and metabolism are important factors that help determine how poisonous a substance will be. While both methyl mercury and arsenic are similar in that they are easily absorbed into the body, they differ markedly in how fast they are excreted.

A key feature of methyl mercury toxicity is its long retention time and bioaccumulation. Arsenic does not bioaccumulate and in fact is excreted from the body very quickly. Approximately half of the absorbed inorganic arsenic is excreted within 10-hours of intake. That does not mean however, that arsenic cannot be bound to molecules and retained in the body. Organic arsenic compounds such as arsenosugars in algae, arsenobetaine in shellfish and

fish, and keratin in hair, nails and skin are well known. Even though the body is very efficient at excreting arsenic, chronic exposure through drinking water can maintain a continuous 'load' of arsenic.

Metabolism, the biochemical changes a chemical undergoes in the body, is also quite different between mercury and arsenic. Methylation of mercury is a requisite process that makes mercury readily absorbable from the intestines. From the intestines the mercury is transported in the blood and ultimately transported across the blood brain barrier into the brain. The blood brain barrier is an anatomical feature of blood vessels entering the brain. The cell walls of these blood vessels consist of tightly packed cells that restrict movement of substances in the blood into the brain. Movement across the membranes of these cells may only be accomplished by substances that are either soluble in the membrane or can be transported across that membrane by a specific transport molecule. This is a specific protective mechanism to restrict harmful agents from entering the brain.

Arsenic does not need to be in an organic form (methyl mercury is a form of organic mercury) to be readily absorbed. Of all life forms, only some forms of bacteria can methylate mercury. In contrast



Photo 5. The Leviathan Mine pit, in eastern Alpine County, is currently undergoing reclamation to ameliorate arsenic and other metals from discharging into Leviathan Creek. Containment ponds are in upper left of photo. For more information about this mine remediation see the article starting on page 26. OMR photo, circa 2001.

many life forms including people can methylate arsenic. Interestingly, some primates like chimpanzees and marmoset monkeys cannot methylate arsenic. Arsenic methylation is not considered a toxifying event.

### **Environmental Sources of Arsenic**

There are several sources of arsenic in the environment, but certain types of mining (especially those containing arsenopyrite) can release high levels of arsenic contamination. Not all mining is associated with high levels of arsenic; in fact the vast majority of active mines are probably inconsequential in this regard.

However, several abandoned mines are superfund sites and have known concentrations of arsenic that are considered hazardous. These sites are currently being remediated under authority of the Comprehensive Resource Conservation and Recovery Act (CERCLA). There are also many abandoned mines, especially in the Mother Lode, where elevated arsenic concentrations may occur, but where we have an incomplete understanding of potential arsenic risk.

In 1994 construction workers building a subdivision located on mine tailings in the Mother Lode community of Sutter Creek, Amador County com-

plained of health problems. The subdivision was built on historic hard rock gold mining tailings that contained elevated concentrations of arsenic. Subsequent soil sampling at the site revealed arsenic concentrations exceeding 500 parts per million (ppm) with at least one sample as high as 1,500 ppm. Extensive clean up was ordered by the EPA and involved removal and or capping of contaminated soils to eliminate exposure.

Since arsenic is so widespread, why be concerned about sources from historic mining activities? Mining accelerates the release of arsenic far exceeding that by natural process. Mine tailings and overburden material present large concentrations of arsenic for release. In reducing environments where oxygen is removed by high acidic conditions, such as the acid mine drainage common at the Leviathan Mine, As III is favored over As V. In low acidic environments, As (III) is the form one would expect to find in water. The 'seep' at Leviathan is the most serious situation, because it releases high concentrations of the most toxic form of arsenic. Remediation of Leviathan is currently under way (Photo 5).

Mercury certainly deserves our attention as an environmental contaminant, but we should not lose sight of the fact that other contaminants

associated with abandoned mines also pose a risk to human health and the environment. Arsenic is one of those contaminants. Arsenic is poisonous to all living things. Environmental methyl mercury exposure to humans results largely from the consumption of contaminated fish, but exposure to arsenic may occur from water, soils, dust and food. Chronic long-term exposure to relatively small amounts may cause health problems including cancer.

A continued surveillance and identification of abandoned mines in California remains a valuable tool in identifying potential sources of arsenic contamination. Water and soil sampling of mines suspected as arsenic point sources would also be useful in assessing risk to human health and the environment.

*Michael Eichelberger, Ph.D.  
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## **Ecological Restoration and the 'R' Words**

Ecological restoration is a concept that has been around for centuries as indigenous people replaced the plants that gave them sustenance. For 100 years beginning in the mid 1800s prominent planners designed parks such as New York City's Central Park in cosmopolitan areas that attempted to imitate natural landscapes.

What is now regarded as the first organized attempt at 'restoration' began in 1934 at the University of Wisconsin, where faculty bought degraded farmland and replanted plants that represented the former 'prairie landscape.' This has become part of the University of Wisconsin's Arboretum.

Now, restoration as a science has emerged on college campuses as degree programs as well in the professional realm of landscaping, farming and forestry. With the incredible loss of natural landscapes due to human interference as well as natural disaster, ecological restoration takes on a new importance. As Aldo Leopold, naturalist, wrote in 1934: "the time has come for science to busy itself with the earth itself. The first step is to construct a sample of what

we had to start with.”

This article describes some of the often confusing and seemingly similar terms that describe the many facets of ecological restoration.

The ‘R’ words: ‘restoration’, ‘reclamation’, and ‘revegetation’ are often used interchangeably, causing confusion among regulators and practitioners. These terms have different definitions. Each ‘R’ word describes a specific method of returning the land to an end use. The words used to describe a project will help to shape goals and outcome of that project. Definitions of these ‘R’ words, as well as words with similar meanings and examples follow:

#### ***Revegetation*** –

Revegetation is a broad term that describes establishing vegetation on disturbed lands. The goal of revegetation can be erosion control, landscaping and/or habitat creation. When an area is revegetated it means that the area has been planted with plants that may or may not be what was growing there before. When the end use is a golf course, the site is *revegetated* with turf grass.

***Reclamation*** – This term refers to improving the conditions on a severely degraded site, usually disturbed by surface-mining, and minimizing the adverse environ-

mental effects by returning the land to beneficial end use. SMARA establishes legislation that provides guidelines for reclamation. Gravel pits are often reclaimed to ponds that serve as wildlife habitat

***Restoration*** – Restoration is the process of intentionally altering a site to establish a defined, indigenous, historic ecosystem. The goal of this process is to emulate the structure, function, diversity and dynamics of the specified ecosystem. Restoration is the most widely misused term. To restore a site means that you are re-establishing the original landscape with its physical and biological components. This process is very difficult because the undisturbed ecosystem is a delicate balance of plants, soil, microbes and wildlife. In California, much work has been done in restoring riparian areas (those areas along rivers and creeks). Riparian restoration is a process that replaces the hydrology, river morphology, soils, and vegetation of the original system in an attempt to fully emulate the predisturbed condition.

***Landscaping*** – Landscaping is a term that refers to the manipulation of the ecosystem for cultural values such as aesthetics and recreational access. Landscaping refers to placing shade trees in a newly created housing development.

***Reforestation*** – Refore-

estation is the process of planting an area with tree species which yield certain wood products. Areas that have been logged or burned are reforested with specific trees such as pine or Douglas fir that can be logged in the future.

***Enhancement*** – Enhancement is a process that improves an already existing ecosystem for a specific value, such as water quality or wildlife habitat. Wetlands that have been degraded by grazing are commonly enhanced by excluding grazing, decompacting and planting wetland vegetation.

***Creation*** – Creation refers to establishing a historical ecosystem on lands that did not previously support that ecosystem (or on severely altered sites). Vernal pools are often referred to as being created. It is controversial whether created ecosystems, such as vernal pools, have the same functional values as their undisturbed counterparts. Some experts contend that created vernal pools over time will not have the same function, vegetation or invertebrates that are found in natural vernal pools.

These words define the method and end use of the area that is going to be repaired. Used correctly, these words can assist in communicating what strategy is used to repair a disturbed site.

The goal of a project can be to simply revegetate the site to control erosion or, with much more effort, to restore the site to a pre-existing ecosystem. The processes and methods to be used to attain these two different goals will be different and need to be considered at the onset.

While a few sites which have been minimally disturbed will recover quickly and adequately by natural processes without any human intervention, revegetation is necessary in most circumstances. Natural reinvasion of a site may take years, during which the disturbed site may erode. Erosion may decrease the capability of the site to support vegetation, continue to degrade visual quality, habitat, and increase dust pollution. Disturbed lands can also cause significant off-site impacts such as increased sedimentation and air pollution, and can act as a noxious weed repository.

Regardless of the level of revegetation being attempted on a site, most projects strive at a minimum to achieve the underlying goal of a self-sustaining vegetative cover that protects a site from wind and water erosion.

*Karen Wiese  
Staff Environmental Scientist  
Reclamation Unit*

*The following article describes Test Plot Guidelines adopted by the Shasta County Department of Resource Management Planning Division in 2002, and is reprinted here with permission.... Editor*

## **REVEGETATION TEST PLOT GUIDELINES**

The following are recommended guidelines for the creation and maintenance of revegetation test plots for surface mine reclamation plans. If there is a conflict between these guidelines and the specific conditions of approval of a reclamation plan, the conditions of approval must be followed or an application for a modification to the reclamation plan must be submitted to, and approved by, the Lead Agency.

### **Why establish test plots?**

The reason to establish test plots is to be able to determine in advance the most successful strategy for revegetation of a mine site. Although a reclamation plan establishes requirements for revegetation, it is not known at the time the reclamation plan is approved whether the approved revegetation will actually be successful.

Test plots help determine which plant species will actually grow on site, and what

soil and nutrients are necessary to achieve revegetation success. Test plots are typically required by reclamation plans.

### **Who is responsible for test plots?**

The mine operator is responsible for establishment, maintenance and monitoring of the test plot. The work may be delegated to a consultant, contractor, employee, etc. However, the operator remains responsible.

### **Where should test plots be located?**

Test plots should be located in an area or areas of the mine where they are unlikely to be disturbed during the rest of the time the mine is being operated. If this is not feasible, then locate test plots in an area which will not be disturbed for at least 4 or 5 years. If possible, the test plots should mimic the ultimate condition of the site. For example, test plots should be located in areas which are representative of the various significant microclimates which may exist on the mine site, such as slope (how steep the finished grade will be), aspect (the direction the slope faces), wet or dry conditions, etc. When possible, the soil or growth media that has been salvaged should be used in the test plots. More than one

test plot area may be necessary to represent all conditions at the mine site.

### What size should a test plot be?

A test plot should be large enough to:

1. Have adequate area to plant a representative sample of the plants proposed for revegetation and enough individuals of each of the plant species to be able to determine the survival and success of the plants to be used for revegetation.

2. Reduce the amount of blown-in seed and invasion of adjacent plants.

3. Have areas for different soil treatments, and planting mixes.

4. Have room for people to monitor the plot without trampling all the plants.

A recommended minimum size is approximately 32 feet by 32 feet, or 10 meters by 10 meters.

### How should a test plot be marked?

A recommended way of marking a test plot is to fence it with welded wire fencing, graduated hog wire or similar fencing, a minimum of 4 feet high, surrounding the plot. A gate and a cleared pathway to the plot are necessary for access.



Preparing the test plot area with an excavator. The following photos show the development of a test plot by Lehigh Southwest Cement at their Falkenbury Quarry, Shasta County (*photos by Bill Walker*).

Fencing your test plot also discourages damage to the plants from browsing mammals. Deer and rodents will be attracted to the tender plants in your test plots and can ruin your data by destroying the plants. Test plot fencing in areas where deer are common should be 6 to 8 feet high. To prevent rodents from burrowing under the fencing, trench 6 to 8 inches beneath the soil surface, under the fence and install chicken wire at the base. Freeze-thaw cycles may damage the chicken wire by pushing it up and out of the soil, so you will need to watch for damage to the fence each spring.

### What type of 'soil' should be used?

Whatever is used for "soil" or growth medium for the test plots should be representative of what will be available and used at the time of reclamation. A test plot planted in native or 'virgin' soil will not be helpful in determining how plants will grow in actual reclaimed mine conditions.

Where possible, soil should be replaced on the test plot in such a way so as to imitate and reconstruct the original soil on site and/or as specified in the reclamation plan. Where possible, coarse rock shall be placed down first, followed by finer rock, followed by subsoil and soil, and capped with topsoil. Soil compaction should not exceed 80



These test plots mimic the final configuration of the slopes.

percent in areas to be revegetated.

Where soil is not available, the test plot should be established on whatever growth medium will be available and replaced in the same way it will be at the time of reclamation.

### **What about soil testing?**

The soil or other growth medium used for reclamation should be tested to determine whether any nutrient amendment or other treatment is necessary. Many soil laboratories will conduct a basic soil analysis for approximately \$30. The soil test will provide you with important information that can save you money in the long run. The soil analysis will determine what your soil pH is. Soil pH is a measurement of

how acidic or how basic your soil is. Plants grow best in soil with a pH of 6.5, but will grow in soils with a pH of 5.5 to 7.5. Mining can alter soil pH by exposing your soils to overburden and tailings, which may contain very acidic or basic minerals. The soil test will also determine if amendments are needed. The soil analyses are based on demands of agricultural crops, so you must extrapolate your results to native plants. Native plants are not adapted to nutrient rich soils. In addition, for many California native species, it may be helpful to inoculate the soil with mycorrhizae.

Fertilizer should be avoided, but if required, any fertilizer that you add should be a slow-release or encapsulated type and at a lower rate than rec-

ommended for agricultural crops. If your soil lacks organic matter, then you may need to increase the organic matter content of your soil by adding compost. Compost should be weed-free.

### **What plants should be planted in a test plot?**

The plants used in the test plots should be the same as the species and density of plants approved in the reclamation plan. You may also consider native plants that are already coming in on the site.

### **What other conditions can I test in my test plots?**

You can test the following conditions:

‘Amended soil’ versus ‘non-amended soil.’ Different trials can include; the use of compost, fertilizer, and soil additives such as lime to raise pH and sulfur to lower pH.

Seeding methods, such as broadcast seeding, hydroseeding, and drill seeding can be tested.

The need for plant protection can be tested outside of your fenced area. Try the different kinds of cages that are available from forestry suppliers.

What species will work best and do they establish quicker as seeds or containerized plants.

The need for weed control and what methods work best.

The need for irrigation, or irrigation the first year to get the plants established.

### **What about irrigation?**

Unless otherwise specified in the approved reclamation plan, permanent irrigation is not recommended. Plants should be planted during the optimum time of year for them to obtain the moisture they need. If possible, avoid irrigation entirely. If additional moisture is needed, periodic irrigation for the first year may be used, keeping in mind that similar irrigation will likely be necessary for the entire mine site at the time of reclamation.

### **How should test plots be monitored?**

The goal is for the test plot to show that if the 'soil' is replaced and the former mine is planted according to the standards and conditions of the reclamation plan, the revegetation will be successful as specified in the plan.

The test plot should be monitored once a year, after the majority of growth has ceased, usually in the late summer. Plots should be monitored the same time each year, and within 2 weeks of the previous year's monitoring. Photographs of the overall plot(s) and of the plants shown next

to a measuring device such as a ruler or tape measure, and showing the date are recommended. Make sure that you keep a record of the success rates of the various plant species, conditions, etc. The record should also compare the actual plant success rates with the success criteria specified in the reclamation plan. A copy of this record should be submitted to the Planning Division and/or provided to the inspector during the annual inspection.

After two or more years, it may become apparent that the survival rate of certain species specified in the reclamation plan is low and/or otherwise does not meet the success criteria for revegetation specified in the reclamation plan. If so, then other soil constructions,

nutrient amendments, irrigation, and/or plant species should be tried. In this case, the operator may apply for and obtain approval of a minor modification to the reclamation plan to change the species to be planted.

### **When should test plots be established?**

A test plot should be established within one year of the beginning of mining operations. In many cases this will allow a number of years of testing prior to reclamation.

### **How long should test plots be maintained and monitored?**

A test plot should be maintained for at least four or five years, and monitored for the



Finished test plots ready for planting.

life of the mining operation. It may be helpful to consider the standard for determining revegetation success:

"The reclamation shall be monitored until the revegetation performance standards are met provided that, during the last two years, there has been no human intervention, including, for example, irrigation, fertilization, or weeding."

*Bill Walker  
Senior Planner  
Shasta County Department  
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## **The Application of SMARA to Surface Mining Operations Relative to Timber Harvest and Forest Management Activities**

When rock materials are needed to facilitate road surfacing or erosion control work relative to timber operations and forest management activities, the question of how the source areas are to be managed may become an issue. To appropriately address the sites during the preparation and review of Timber Harvest Plans (THP) and other forest management activities, the location of the mineral resource must be considered, and the agency primarily responsible for overseeing the site and the strategy to be applied in recla-

mation needs to be resolved. The identification of the rock source and the approvals necessary should be resolved early in the THP preparation process.

### **Surface Mining and the Lead Agency System**

The Surface Mining and Reclamation Act (SMARA) defines mining to include the removal of overburden and excavation directly from a mineral deposit, or the open-pit excavation of minerals that are naturally exposed. Borrow pitting, streambed skimming, and segregation and stockpiling mined materials (and recovery of same), all are deemed to be surface mining operations. According to SMARA, surface mining activities may include the surface, subsurface, and ground water of an area in which surface mining operations are conducted, including private ways and roads appurtenant to the area, and any land excavations, workings, mining waste, and areas in which structures, facilities, equipment, machines, tools, or other materials or property which result from, or are used in, the surface mining operations are located.<sup>1</sup>

The state agencies that implement SMARA are the Department of Conservation (DOC)'s Office of Mine Reclamation (OMR) and the State Mining and Geology Board (SMGB). However, at the local level,

<sup>1</sup> SMARA Sections 2735 and 2729

California employs a "lead agency" system to regulate surface mining activities. The lead agency responsible for regulating mining, relative to timber harvesting activities, is generally the local County Planning Department.<sup>2</sup> Each county in California and many city governments exercise local control over surface mining activities.<sup>3</sup>

In 1994, SMARA was amended to exempt certain surface mining activities that occur in conjunction with timber harvest operations on non-federal land.<sup>4</sup> These exemptions allowed some sites, that meet specific criteria, to be exempted from regulation under SMARA and the lead agency system, and instead to be regulated by the California Department of Forestry and Fire Protection (CDF).<sup>5</sup>

### **Size, Location and Utilization Criteria**

The following questions should be asked of surface mining operations during the preparation and approval of a THP or associated forest management

<sup>2</sup> THP preparation with SMARA regulated rock sources commonly occur within — but are not limited to — Humboldt, Del Norte, Trinity, Mendocino, Sonoma, Marin, San Mateo and Santa Cruz counties and other mountainous counties in California.

<sup>3</sup> SMARA is also applicable on federally owned land within California. The State has signed Memorandums of Understanding with the USFS and BLM so that SMARA standards are met.

<sup>4</sup> Chapter 680, Statutes of 1995

<sup>5</sup> SMARA 2714(j)



The Barn II Quarry near Kneeland in Humboldt County is a greenstone outcrop in the Franciscan Complex. It was developed in late 1998 to provide ballast for maintaining Pacific Lumber Company roads. Unless plans to use the site for commercial applications are approved, the site will continue to be used exclusively for forest management and will remain exempt from SMARA (*photo by Mike Sandeck, 2002*).

If the disturbance does not cumulatively reach the 1,000 cubic yard or one-acre threshold, the activity is not regulated as a mining activity by either a SMARA lead agency or by CDF, regardless of its location relative to a watercourse.

The site is exempt from SMARA where the excavation and grading is done exclusively for obtaining materials for timber harvest roads or forest management activities, and if the footprint of surface mining disturbance is further than 100 feet away from any Class 1 Watercourse or 75 feet away from any Class 2 Watercourse. The mining site must also be situated on land owned by the same person or entity that is conducting the timber operations or forest management activities. These sites are exempted from SMARA and exclusively subject to CDF jurisdiction and regulated under the Forest Practices Act. However, if any part of the mining disturbance also falls within the stipulated stream buffer, or any portion of the material produced at the site is used for commercial purposes, the mining activities are subject to SMARA.

### Management Strategy

If an activity is defined in SMARA as a surface mining operation and isn't exempt under the definitions in SMARA (exceeding the SMARA 1,000 cubic yard or one-acre threshold) and the Forest Practice Rules, the SMARA lead

#### activities:

- Does the acreage disturbed by mining exceed one acre in size or has more than 1,000 cubic yards per location been mined?<sup>6</sup>
- Is the excavation or grading done for the exclusive purpose of obtaining materials for road-bed construction and maintenance conducted in connection with timber operations or forest management (not sold for commercial purposes) on land owned by the same person or entity?
- Does the footprint of surface mining disturbance fall within 100 feet of a Class 1 Watercourse or 75 feet of a Class 2 Watercourse?<sup>7</sup>

#### SMARA or CDF Jurisdiction?

If the disturbed area exceeds one acre in size or the cumulative volume of material mined exceeds 1,000 cubic yards per location, the site meets the threshold criteria as a surface mine.

If the footprint of the area disturbed by surface mining falls within 100 feet of a Class 1 Watercourse or within 75 feet of a Class 2 Watercourse, or if the rock source is not exclusively used for timber harvest operations on the same property ownership, the surface mining activities are regulated in accordance with SMARA, usually by the local lead agency.

<sup>6</sup> SMARA Section 2714(d)

<sup>7</sup> Stream Classes are defined in the Forest Practice Rules, CCR Sections 916.5, 936.5 and 956.5

agency should be notified by the project proponent or agent during the course of the THP preparation process. The project proponent or agent should advise the SMARA lead agency and CDF of any mining activity relative to their individual THP or forest management activity.

- Lead agencies are charged with the regulation of mining activities within their local jurisdictions, with DOC acting as an oversight agency both for enforcement and technical help. Generally, the approval of a mining operation by a lead agency is subject to a permit<sup>8</sup> and both the permit and reclamation plan approval must be reviewed by the lead agency as a project under the California Environmental Quality Act. In the process of preparing the THP, it should be realized that these provisions must be in place before the site may be utilized.
- Using the directives provided in SMARA, the lead agency's mining ordinance, which must be certified by the SMGB, governs the mining and reclamation activities. Usually the local mining ordinance parallels the standards set forth by the State Mining and Geology Board in SMARA and the California Code of Regulations (CCR)<sup>9</sup>, however the ordinance may also set standards more stringent than the

minimum state regulations.<sup>10</sup>

- In order to comply with SMARA, all requirements for reclaiming a surface mine that have been adopted in the local mining ordinance must be included in the reclamation plan and applied at the site. If a reclamation plan is (or was) approved after 1993, minimum standards for backfilling and grading, resoiling, slope stability, revegetation, and stream protection are required to be met.<sup>11</sup> Because local mining ordinances are allowed to have more stringent requirements than the CCR, it is prudent to be aware of the county standards. It can also be helpful to contact the County Planning Department to determine site's status, and to investigate the specific requirements of the reclamation plan. OMR can also supply this information.
- The lead agency must initially determine whether either the one-acre or 1,000 cubic yard SMARA threshold has been exceeded. The thresholds are considered to be cumulative over the life of the surface mining activity, beginning at the time of the institution of SMARA in 1976. The lead agency must also determine whether or not the site is used exclusively for the purpose of timber harvest on a single landholding, or alternatively, if the material will enter and compete in the commercial

aggregate market.

If an activity is exempt under the criteria specified in SMARA, and reflected in the provisions of the Forest Practice Rules, the project proponent, in consultation with CDF, must apply specified SMARA standards in their operations, as follows:

- Cut slopes, including final highwalls and quarry faces, must have a minimum slope stability factor of safety that is suitable for the proposed end use and conform to the surrounding topography and/or approved end use.<sup>12</sup>
- Surface runoff and drainage from surface mining activities must be controlled by berms, silt fences, sediment ponds, revegetation, hay bales, or other erosion control measures, to ensure that surrounding land and water resources are protected from erosion, gulying, sedimentation and contamination. Erosion control methods must be designed to handle runoff from not less than the 20-year/one hour intensity storm event.<sup>13</sup>
- Upon closure of any SMARA-exempt timber harvest rock source site, the person closing the site must implement revegetation measures and post-closure uses.<sup>14</sup>

*Michael Sandeck  
Staff Environmental Scientist*

<sup>8</sup> If an operation began prior to January 1, 1976, when SMARA went into effect, a vested right may have been established. In this case, no permit, or no additional permit other than that held at the time the site was granted vested status, may be needed other than the approval of a reclamation plan pursuant to SMARA.

<sup>9</sup> Title 14, Chapter 8, Article 1, Section 3500 *et seq.*; Article 9, Section 3700 *et seq.*

<sup>10</sup> For example, Mendocino County's Mining Ordinance also cites that any surface mining within 50 feet of a Class 3 Watercourse is also subject to SMARA and non-exempt. However, while SMARA allows local land uses to be more stringent, it is currently debated in the courts whether or not local regulations more restrictive than those regulations cited in the Forest Practices Act may be applied to forest management activities.

<sup>11</sup> Article 9 CCR Section 3700 *et seq.*, Reclamation Standards

<sup>12</sup> CCR Section 3704(f)

<sup>13</sup> CCR Section 3706(d)

<sup>14</sup> SMARA Section 2714(j)(2)

## GOT DATA? RECLAMATION PLANS MADE EASY

Reclamation Plans for surface mines can be challenging to write because the task requires the collection of a wide variety of current and historic information. The information needed varies depending on the environmental setting and proposed operations for each mine site. New, easier to use information is constantly being developed and is available on the internet. This article provides a list of useful websites that contain environmental and engineering information frequently needed to produce a reclamation plan.

Reclamation means the combined process of land treatment that minimizes water degradation, air pollution, damage to aquatic or wildlife habitat, flooding, erosion, and other adverse effects from surface mining operations. Reclamation must be geared toward the ultimate or 'end-use' of the mine site.

A reclamation plan must be specific to a piece of property. The plan should describe how the specified course of reclamation might affect the existing and future uses of the surrounding area. Future use can run the gamut from preservation of open space and habitat restoration to



The author evaluating whether or not instream gravel mining contributed to channel incision and bank destabilization along Grist Mill Creek, Mendocino County. Note how the exposed roots sticking out of the bank at the far middle right of the picture reflect relatively recent soil loss. The tall trees that line the riparian zone beyond the limits of the mine may become 'collateral damage' should the stream cut the bank enough to cause them to topple. *Photo by Mike Sandeck, June 2004.*

urbanization and industrialization.

The California State Mining and Geology Board established requirements for the basic contents of reclamation plans. The reclamation plan must establish site-specific criteria to achieve mandated performance standards. The performance standards include the following topics: 1) wildlife habitat, 2) slope stability, 3) revegetation, 4) erosion control, and 5) protection of the water resources. Many of the performance standards are interrelated. For example,

erosion control is essentially the control of water and sediment. When erosion is unchecked, slope stability and water quality often degrade.

The websites listed below provide important background information needed to develop a reclamation plan and criteria for the required performance standards. The websites are grouped according to the most applicable performance standards. Each website may apply to other performance standards or simply provide useful general information.

## WILDLIFE HABITAT and REVEGETATION

Wildlife data, including lists of rare, threatened, and endangered species, can be accessed through websites maintained by the Department of Fish and Game and other organizations. A key component of wildlife habitat is the native plant communities. Revegetation is fundamental to erosion control and reclamation. At all times, the introduction of invasive weeds should be avoided. When the end-use of the site is designated as either open space or habitat, native plant communities are preferred because they are usually self-sustaining, adapted to the local climate and soils conditions, and provide natural habitat values for wildlife.

The Atlas of Biodiversity provides useful regional descriptions of wildlife habitat and the Rare-Find 3 database allows the subscribers to search for site-specific information contained in the California Natural Diversity Database (CNDDDB). CalFlora and the Native Plant Society provide useful information regarding plants and plant communities. The Jepson Manual and the RareFind 3 database are standard tools for biologists.

### ***Department of Fish and Game***

<http://www.dfg.ca.gov/regions/regions.html>

<http://www.delta.dfg.ca.gov/afrp/projects.asp>

<http://atlas.dfg.ca.gov/>

<http://www.dfg.ca.gov/whdab/html/rarefind.html>

### ***Other Organizations***

<http://www.calflora.org/index0.html>

<http://ucjeps.berkeley.edu/>

<http://ceres.ca.gov/>

<http://www.cnps.org/>

<http://pacific.fws.gov/ecoservices/>

### ***Weeds***

[http://groups.ucanr.org/ceppc/Pest\\_Plant\\_List/](http://groups.ucanr.org/ceppc/Pest_Plant_List/)

Water resources must service the sometimes-incompatible needs of the natural environment and the demands of society. Throughout the State, there are many river engineering and river restoration projects underway with a goal to balance needs (i.e., flood control, storage, water transfer) and impacts (e.g., spawning gravel depletion, loss of wetlands). Learning what's happening in your watershed can help in the selection of a compatible end-use for a mine site. The following websites provide quick access to statewide maps of watersheds and projects.

***Learn About Your Watershed***<http://cfpub.epa.gov/surf/locate/index.cfm>***Locations of Restoration Projects***<http://yosemite.epa.gov/water/restorat.nsf/California?OpenView><http://www.epa.gov/owow/wetlands/restore/>***Locations of Army Corps of Engineers Projects***<http://www.spd.usace.army.mil/>**SLOPE STABILITY**

Slope stability is often a very important issue during the operational life of a mine (50 years is common) and afterwards regarding its end-use. Reclaimed slopes often must remain stable over the long term, even during earthquakes. Unstable slopes are slopes prone to accelerated erosion ranging from the surficial effects (rills and gullies) of rainwater runoff to deep-seated, large-scale landslides such as the collapse of a mine wall. Successful revegetation of mine slopes goes hand-in-hand with stable soils to minimize slope erosion.

In urban areas or areas of rapid development, the risk of injury and property damage due to unstable slopes (now or in the future) can be high. For future development, unstable slopes are problematic since mitigations may be costly and may constrain future use and value of the land. In remote areas where risk to the public and property is minimal, a higher level of instability may be tolerable.

Assessment of long-term slope stability and risk is very complicated due to a high level of uncertainty. The uncertainty results from the wide range of natural phenomena (such as earthquakes, floods, and storms) that affect slopes, our limited ability to accurately characterize conditions hidden beneath the ground, and the challenges of predicting the future.

Numerical modeling of slope stability attempts to offset the uncertainties by utilizing a 'factor of safety' approach. This approach is based on considerable experience and is widely accepted. Regulatory slope stability requirements are stated in terms of minimal factors of safety. Typically, the effects of earthquake shaking must be factored into the evaluation. Final excavated slopes must achieve a factor of safety compatible with the designated end use.

Due to the complications and risks, slope stability analyses, when required, must be performed by professionals (Geotechnical Engineers, Engineering Geologists, or Professional Engineers) licensed to practice in the State of California. The Department of Consumer Affairs maintains websites that include directories for licensed geologists and engineers.

The following two websites allow the user to search the directory of licensed geologists and engineers.

***California Board of Geologists and Geophysicists***

<http://www.geology.ca.gov/>

***California Board of Professional Engineers and Land Surveyors***

<http://www.dca.ca.gov/pels/>

The following websites provide useful information and guidelines regarding slope stability analysis.

***Rock Mechanics***

<http://www.rocscience.com/hoek/Hoek.asp>

***Guidelines for Evaluating and Mitigating Seismic Hazards in California***

<http://gmw.consrv.ca.gov/shmp/SHMPsp117.asp>

***Recommended procedures for implementation of DMG Special Publication 117***

<http://www.scec.org/resources/catalog/hazardmitigation.html#land>

The following websites provide considerable detailed information needed to evaluate earthquake forces that may influence slope design.

***Alquist-Priolo Act, Affected Counties and Cities***

<http://www.consrv.ca.gov/CGS/rghm/ap/affected.htm>

***Fault Evaluation Reports***

[http://www.consrv.ca.gov/CGS/rghm/ap/ap\\_fer\\_cd/index.htm](http://www.consrv.ca.gov/CGS/rghm/ap/ap_fer_cd/index.htm)

***Probabilistic Seismic Hazards Map***

<http://www.consrv.ca.gov/CGS/rghm/psha/index.htm>

## **EROSION CONTROL**

Site-specific erosion control criteria are an integral part of a Reclamation Plan. They are also integral to Stormwater Pollution Prevention Plans (SWPPP) required by the Regional Water Quality Control Boards. Despite similarities, the scope of Reclamation Plans and SWPPPs differ significantly. For example, a SWPPP is chiefly concerned with polluted runoff during operations, while the main focus of a Reclamation Plan is long-term stability to maintain the site's compatibility with its designated end-use.

Erosion control plans need to consider local climatic conditions, especially precipitation and runoff, in order to determine proper sizes for erosion control structures. Erosion control plans should include designs and descriptions of the methods to be used on-site. Many well accepted methods of erosion control have been gathered into collections of standard designs

known as Best Management Practices (BMPs). BMPs can be easily incorporated into erosion control plans as prescriptions to be applied to specified site conditions or locations. In other words, the erosion control plan should specify when and where selected BMPs would be incorporated.

**Construction Stormwater Program**

<http://www.swrcb.ca.gov/stormwtr/construction.html>

**National Pollutant Discharge Elimination System**

<http://cfpub.epa.gov/npdes/>

**California Stormwater Quality Association, 2003, Stormwater Best Management Practice Handbook: Construction**

<http://www.cabmphandbooks.com/Construction.asp>

**Stormwater Manager's Resource Center**

<http://www.stormwatercenter.net/>

**Department of Interior, Office of Mines**

<http://www.ott.wrcc.osmre.gov/library/hbmanual/design/designmanual.pdf>

**CalTrans Manuals**

<http://www.dot.ca.gov/hq/construc/stormwater/manuals.htm>

**Best Management Practices for Mining**

<http://www.dnr.wa.gov/geology/pdf/bmp.pdf>

## PROTECTION OF WATER RESOURCES

The State and Regional Water Quality Control Boards oversee the protection of water resources in California. Data regarding water resources is available from the U.S. Geological Survey (USGS), Department of Water Resources (DWR), U.S. Environmental Protection Agency (USEPA), and the Water Quality Control Boards. Many watersheds in California have been designated as impaired by sediment or other pollutants.

**Water Quality Control Boards**

<http://www.swrcb.ca.gov/regions.html>

**Impaired Watersheds 303(d) Lists**

[http://www.swrcb.ca.gov/tmdl/303d\\_lists.html](http://www.swrcb.ca.gov/tmdl/303d_lists.html)

<http://www.geotracker.swrcb.ca.gov/>

Groundwater is important in mining for several reasons, as a source of water, as a resource to be protected, and as nuisance to deep operations. Reclamation plans should identify the quantity, source, and disposal of water. Excavations that extend toward groundwater levels require special considerations regarding saturation, flooding, slope stability, contaminant migration, and flow interception. Reclamation may require the abandonment of water wells, dewatering systems, and drainage controls. These water facilities need to be illustrated on reclamation plans and their ultimate closure needs to be addressed.

DWR, the USEPA, and the USGS maintain searchable databases and references that are easily accessed via the internet.

***Historic Well Locations and Records and Water Quality Data***

<http://wdl.water.ca.gov/>

***USEPA Region 9***

<http://www.epa.gov/region09/water/>

<http://www.epa.gov/region09/library/index.html>

***Regional Groundwater Information***

<http://www.groundwater.water.ca.gov/bulletin118/index.cfm>

<http://nwis.waterdata.usgs.gov/usa/nwis/gwlevels>

Some mines, particularly sand and gravel mines, are located in areas subject to occasionally intense flooding and attendant erosion and sediment deposition. In fact, along stream channels and coastlines, it can be difficult to ascertain the importance of flooding and hydrology to reclamation. Because hydrological conditions are as variable as the weather, it is important to review historic records to understand the range of variability, especially considering the long-term focus of reclamation plans. The Desert Research Institute maintains a virtual one-stop-shop for meteorological data.

The National Oceanographic and Atmospheric Administration (NOAA) maintains tidal and storm surge records. The Federal Emergency Management Agency (FEMA) and Department of Water Resources (DWR) produce and update floodplain maps based on current conditions and historic records. The US Geological Survey (USGS) and DWR operate stream gages throughout the state. Sediment transport has long been recognized as a key concern in managing stream channels. Instream sand and gravel mines must balance extraction with the local sediment budget to prevent undue impacts. Both the USGS and Bureau of Reclamation (BOR) have collected and maintain sediment transport data for many parts of the state.

**Western Regional Climate Center, Desert Research Institute**

<http://www.wrcc.dri.edu/>

**Tide Data**

<http://tidesonline.nos.noaa.gov/geographic.html>

**Floodplain Mapping**

[http://www.fpm.water.ca.gov/mapping/awareness\\_mapping.html](http://www.fpm.water.ca.gov/mapping/awareness_mapping.html)

<http://www.fema.gov/fhm/>

**USGS Water Data for California**

<http://waterdata.usgs.gov/ca/nwis/nwis>

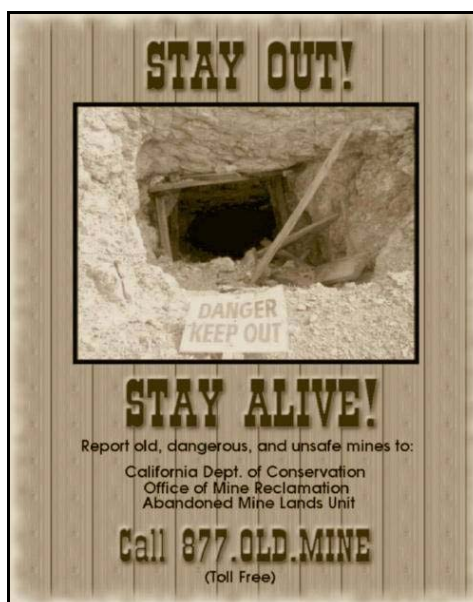
**USGS Active Stream Gages**

[http://water.usgs.gov/nsip/nsipmaps/ca\\_base.html](http://water.usgs.gov/nsip/nsipmaps/ca_base.html)

**USEPA Watershed Data**

<http://cfpub.epa.gov/surf/locate/index.cfm>

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## THE LEVIATHAN MINE, ALPINE COUNTY

### Site Description

Leviathan Mine lies within the Bryant Creek (interstate) watershed at an elevation of 7,000 feet. The site is located in Alpine County. Approximately 265 acres of barren and eroding disturbance remain at Leviathan Mine as a consequence of mining operations.

The sparsely vegetated disturbance consists of an open pit, overburden and mining waste piles. The barren conditions of the site ultimately increase Acid Rock Drainage (ARD) generation, pollutant transport, and slope instability. Low pH ARD containing high concentrations of dissolved sulfate, arsenic, nickel, aluminum and iron is discharged to Leviathan and Aspen creeks from the channel underdrain, pond overflows and seeps.

The unvegetated site has many long and steep slopes which are highly susceptible to erosion. Erosion generates sediment loads that are delivered to Aspen and Leviathan creeks by runoff, and that threaten on-site improvements by blocking surface drainage structures.

The impact of discharges from Leviathan Mine has been sufficiently demonstrated by the continuing water quality monitoring program. Affected water



Test plot revegetation program in the Leviathan Mine pit floor.  
*Photo by Karen Wiese, circa 1997.*

bodies are Leviathan Creek, Aspen Creek, Bryant Creek, and the East Fork of the Carson River. These water bodies are listed as 303(d) impaired. The length of severely impacted water quality and contaminated sediments extend beyond the California/Nevada state line.

The site is in a remote area of the eastern slopes of the Sierra Nevada where utility services are unavailable. Evidence of vandalism is readily apparent at the site and has often required costly repairs. The area is also seismically active. Open pit mining operations created site instability evidenced by several landslides; one of these is over 100 acres in aerial extent.

### Mining Operations

Extracting minerals needed for

processing more valuable ore mined in Nevada was a recurring theme. The mine had several owners and produced copper and sulfur. Initial mining efforts at Leviathan were underground. During subsurface operations Leviathan was mined for copper sulfate, copper, and sulfur, respectively.

Comstock Lode miners discovered the Leviathan Mine and developed the first workings in 1863. By 1869, miners became interested in the showing of primary copper minerals. In 1935, Calpine Corporations of Los Angeles began subsurface sulfur mining.

Anaconda Copper Mining Company purchased Leviathan Mine in 1951 for sulfur mining by open-pit methods. The sulfur was needed for processing copper ore at Ana-

conda's Week Heights Mine near Yerington, Nevada. Isabell Construction Company began stripping overburden from the sulfur ore body in 1952.

Anaconda stopped mining operations in late 1962, 13 years before the Surface Mining and Reclamation Act, and sold Leviathan Mine to Chris Mann, the Alpine County Clerk in 1963. Approximately 22 million tons of overburden containing large quantities of low grade sulfur ore were spread over more than 200 acres without any classification, separation, or original ground surface preparation. Anaconda created a 26-acre waste dump more than 130 feet in depth by disposing waste rock, consisting of low grade ore from mining operations, in the Leviathan Creek canyon. Leviathan Creek flowed around and seeped through the waste dump. The final mined 50-acre pit was roughly 2,000 feet long, 1,000 feet wide, and a maximum of 400 feet deep.

### Site Acquisition

When first looking for project funds, the Lahontan Regional Water Quality Control Board (LRWQCB) learned that, to obtain a Federal demonstration grant, the project proponent must be able to assure site access and continued project operation. From this, site ownership developed into a Regional Board objective. On December 19, 1993, Alpine Mining Enterprises deeded 23 pat-

ented land claims and the Leviathan Mill site claim to the State of California. The State Public Works Board authorized acquisition of Leviathan Mine with a resolution dated January 31, 1984 and transferred jurisdiction of Leviathan Mine to the State Water Resources Control Board in a letter dated August 20, 1984. The site is managed by the LRWQCB.

### Abatement Project

The pollution abatement project (implemented in 1986/87) resulted in extensive areas of deep compaction which prevented revegetation allowing erosion of the site to continue. Slope erosion contributes to sedimentation of the surface drainage structures constructed within the pit, around the evaporation ponds, and along the slopes below the ponds. Each year maintenance work is required to clear the surface drainage structures of sediment and to regrade and repair the dirt access roads.

### Current Efforts

Through funding from the State Water Resources Control Board Contract Agreement Number 6-076-256-0, the State of California Department of Conservation, Office of Mine Reclamation (DOC), in collaboration with the LRWQCB and the University of California, Davis, Department of Land, Air, and Water Resources (UCD), have developed a revegetation strategy

for Leviathan Mine.

The principal objectives of this strategy are to: (1) establish a self-sustaining native vegetative cover that will help to ameliorate degradation of water quality in Leviathan and Aspen creeks by establishing vegetation that intercepts precipitation and controls the release of contaminated sediments and ARD, and (2) increase the evapotranspiration of atmospheric water out of the pit slopes, overburden and tailings piles by deep-rooted perennial vegetation.

Soil remediation work was handled by UCD, plant-related revegetation work was conducted by the DOC, and overall management, in-kind support, and matching funds were provided by the LRWQCB. The revegetation strategy is based on a combination of the following four components: (1) soils ripped and amended to depth, (2) site-specific plants, (3) microbial symbionts, and (4) plant protection. It is the combination of these four components that make this strategy successful and different from previous attempts at revegetation. The Office of Mine Reclamation monitored the test plots installed in 1997 and completed a final report with the test plot results and recommendations.

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Our web site address is <http://www.conservation.ca.gov/omr>. The purpose of this publication is to impart the latest reclamation tips, as well as changes in SMARA-related legislation or interpretation of existing statutes by court decisions.

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Large excavation benches at the U.S. Gypsum Fish Creek Mountain Quarry in Imperial County, about 70 miles east of San Diego. This Miocene age gypsum deposit is one of the largest in the world. The quarry and deposit is located at the north end of the Fish Creek Mountains. In the mine area, the gypsum beds have been preserved in a shallow synclinal basin 3 miles long and a half mile wide. Once mined, the nearly pure massive gypsum is transported via a private narrow-gauge railway to a calcining plant at Plaster City, about 25 miles to the south. The calcined gypsum is primarily used to make several varieties of wall-board and is extensively marketed throughout the United States and to numerous foreign countries. *Photo by Bob Hill, circa 1991.*